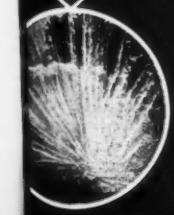
CHEMISTRY



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Who Needs Chemistry?

▶ FOR WHAT kinds of work are the young people in school preparing themselves?

Certain specially talented ones know that they are already headed toward research careers in science. But many who feel that they are looking for jobs, not careers, need a background of chemical training. As chemistry takes over the task of supplying materials to replace those formerly obtained from nature, everybody must become familiar with new techniques for handling the new synthetics.

Today's students training for the professions will be helped by the chemistry courses they take. For medicine they are essential. For law they will be useful in innumerable ways in addition to the obvious application to patent cases. For government there is urgent need of the scientific outlook on the part of our lawmakers.

Students who do not want to specialize too much, but enjoy science as a whole should go into teaching. Here too the need for the scientifically trained is acute.

As industries branch out into more and more varied types of chemical manufacture, more jobs are created for which technical understanding is an asset. Technical skills are necessary for the control lab. technicians and the production workers. Familiarity with processes and materials is necessary for the purchasing department and the stockroom. Understanding the technical vocabulary is an asset to those with clerical and secretarial training. The advertising department and the sales force are more valuable in proportion to the technical assistance they can give prospective customers.

From executives to cleaning crews, everybody is benefited by knowing more about the materials handled and the products manufactured. Is there anybody who wouldn't be helped by a course in chemistry?

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▶THE SURFACE *of the new-born earth resembled more this landscape of the moon than a virtual hell of belching volcanoes. The young earth was pelted and marked by meteor falls, just as was the moon, as can be seen in this U. S. Naval Observatory photograph.*

Chemical Origin of Life

by HELEN M. DAVIS

▶LIFE as a chemical phenomenon may be no more mysterious than the appearance of flame when fire is kindled. Death and destruction may be no stranger than the disappearance of steam as the kettle boils dry.

The zest for living with which you start the day may be just a form of the chemical reaction which is you.

Other chemical reactions, whether they are the quiet precipitation of a salt in a test tube or the searing flash of an atomic bomb explosion, come about when the right conditions exist. If we can learn those conditions, why should we not be able to create life-endowed matter out of laboratory chemicals?

Each new advance in science that might shed light on the origin of life finds scientists again arranging conditions according to their new understanding, hoping that this time the experiment will succeed.

Early users of the microscope hoped that, as they explored the new world of strange creatures just made visible, they would find the answer. They succeeded in finding the cells which begin the life of each individual. But these are living cells which carry life on from generation to generation. Attempts to bridge the gap between them and non-living matter failed. The project was declared impossible.

The statement that life has no beginning aside from "special creation" became an axiom, like the laws of the conservation of mass and the conservation of energy. Everybody said "matter can neither be created nor destroyed" and, correspondingly, "energy can neither be created nor destroyed."

But, with the start of the first nuclear chain reaction, on Dec. 2, 1942, these laws of conservation were swallowed up in the larger knowledge that mass and energy are one.

One of the scientists who worked on the release of nuclear energy was Dr. Harold C. Urey, professor at the Institute of Nuclear Studies, University of Chicago. He is widely known as the discoverer of deuterium, or "heavy" hydrogen, for which he received the Nobel Prize.

After our conquest of the energy inside the atom, thought Dr. Urey, why not turn our new understanding of chemical energy once more toward the origin of life?

From personal experience we know that life exists on this earth in myriad forms. Scientists who have learned the way nature operates can tell us more. Biologists can tell us that they do not consider it impossible for some enzyme or virus to cross the line between life and the non-living, but they have not seen it happen.

Geologists tell us that the many kinds of living creatures on earth took a long time to evolve to their present forms. Astronomers tell us that we live on one of the smaller planets of a second-rate sun in one of many galaxies, and that both suns and galaxies are in evolution.

Dr. Urey is gathering evidence from all these sciences to piece together a picture of our earth when life began. He believes that primordial earth may have been at a very high temperature at one time, a flaming ball of melted rock, but when it cooled off the cold body was surrounded by an atmosphere of reducing gases — methane, ammonia, hydrogen and water.

Hydrogen as a gas is very abundant throughout space. Astronomers can detect it easily with a spectroscope. But there is practically none of it in earth's atmosphere at the present time. If a chemist wants some, he has to get it by breaking up water or one of the other compounds in which it is locked up.

Methane or marsh gas and ammonia are not present in the earth's atmosphere today except as mere traces, quickly dissipated. But they are in atmospheres of other planets, including Jupiter and Saturn, spectroscopic astronomical observations tell us.

Our present atmosphere is oxygen and nitrogen. Dr. Urey believes that

the change in the type of atmosphere came about when life started. The change was a radical one, for the two gases are very different. Oxygen burns many substances, even metals to form rusts. Hydrogen combines with few metals, but it burns in oxygen to form water. So energetic is the attraction of hydrogen for oxygen that it will break up rust, restoring the metal to its original form.

Chemists refer to the burning as *oxidation*, and say that hydrogen *reduces* the rust to metal. Atmosphere predominantly of hydrogen would be a reducing atmosphere, where oxygen would burn and stay combined as water vapor, but iron would not rust.

Iron, when exposed to our present atmosphere of oxygen and water vapor, rusts away. Yet evidence of several different sorts makes geologists believe that, deep down, our whole earth is about 40% by weight a metallic iron ball. Silicate rock extends from the earth's surface to about half the way to the earth's center. When the earth was formed, was it the envelope of reducing gases that protected the iron of the original earth, and kept it from crumbling away into red dust?

Isolated as we are in space, we have but two ways to study the appearance of other planets of our system. One is by looking at the moon. The other is by examining the chance samples of planetary material that fall to earth as meteorites.

Meteorites are of two kinds. Some are silicates, like the rocks of earth's surface. The rest are iron of a special type, containing a large amount of nickel. As a chemist, Dr. Urey can tell from the appearance of these interplanetary samples whether they were formed hot or cold. From the appearance of the moon, he can imagine how the earth may have looked in its early stages. From studying the "craters" on the moon, he discards the old idea that they represent volcanoes, and sees them as scars of meteor falls on the moon's surface.

But many of the ideas that Dr. Urey is advancing now are old ideas, too, advanced 60 years ago by the geologist, G. K. Gilbert. Dr. Urey feels that people have refused to read about them, reason about them, and understand them.

Fewer explosions, fewer cataclysms, more quiet building up by slow accretion is the pattern of creation as Dr. Urey sees it. Less fire, more ice.

Earth starts, then, in a cloud of hydrogen and other reducing gases. All the other chemical elements are mixed in the thick scum of slag that frosts its surface. The cloud of hydrogen and other gases is bathed in sunlight. What forces can change this cold metallic world into the green earth we know?

Energy from the sun, then as now, can trigger chemical change. It can split the molecules of water vapor in the atmosphere. Oxygen from that source can begin its circling dance among the elements, with first one partner, then another. But hydrogen long remains the most abundant gas, and the reducing atmosphere persists. How, under these conditions, can the earliest compounds form which lead toward life?

Building organic compounds in a reducing atmosphere, Dr. Urey and one of his colleagues are actually working on this problem at the pres-

ent time. They find their results promising. The kinds of compounds they believe must have been the first to form can actually be made under the conditions they believe existed. How far these progress on the road toward life is what they are trying to learn.

In an apparatus in the University of Chicago chemical laboratories, methane, ammonia, water and hydrogen were circulated past an electric discharge, duplicating the play of forces upon the matter of the new-born earth. By chromatographic analysis, Dr. Stanley L. Miller, a National Science Foundation fellow working with Dr. Urey, found that glycine and two other amino acids were formed and there were hints of other such compounds. This is the very stuff of living matter, building blocks of proteins.

Once chemists were hopeless about trying to make any of the chemicals produced by living processes. They imagined a force they called "vis viva" which was necessary to make the elements combine into organic matter. When Wöhler, in 1828, made from inorganic chemicals the same urea that is excreted by animal bodies, the mystery of organic synthesis became merely a particular case of chemical know-how.

Dr. Urey and his colleagues are extending present-day chemical know-how to meet new problems in organic synthesis. When the right combination of matter and energy is found, chemical reactions usually "go" of themselves.

Will the compounds these chemists are making pick up the energy to nourish themselves? Will they, perhaps, become endowed with the green plant's capacity for photosynthesis? Will they, by division, create more of their kind in their own image? And if so, will they start a new line of evolution, leading — whither?

Conquest of the laws of life may prove no more difficult than that of organic chemistry. If so, it will contradict the fears of those whose imagination would limit the power they ascribe to the Creator.

New Material in Meteor Crater

➤ DISCOVERY of a new kind of material formed when a meteorite smashed out Arizona's famous huge crater has been made by Dr. H. H. Nininger, director of the American Meteorite Museum at Winslow, Arizona.

The new product is in the form of teardrop-shaped pieces and irregularly twisted cinder-like masses, all apparently loaded with particles of nickel-iron, Dr. Nininger reports.

Although the frothy pieces have been spotted many times before, it was always thought that they resulted from the action of nearby volcanoes. Now, Dr. Nininger states, laboratory tests have shown that instead of lava, the "bomblets" are frothy glass in which are embedded tiny spherules of nickel-iron.

Nerve War Gas Tried On Human Volunteers

Symptoms of Nameless War Gas

HUMAN volunteers have now gotten, in small doses, a chemical killer that may equal the atom bomb as a military weapon of destruction.

Who the volunteers are, whether soldiers, doctors, medical students or other persons, is being kept secret by security regulations.

The chemical itself does not even have a name that can be told. It was called just "nerve gas" when Dr. A. McGehee Harvey reported to the American College of Physicians results of the tests on volunteers which he and his associate, Dr. David Grob, of Johns Hopkins School of Medicine, Baltimore, made under contract with the Army Chemical Corps Medical Laboratories.

The nerve gases are, chemically, organic esters of phosphoric acid derivatives. Some chemicals of this general group have been widely used as insecticides. These are known as parathion, TEPP and HETP.

The nerve gases are among the most potent of the known chemical warfare agents and are also the most adaptable to long range attack, as upon civilian populations, Dr. Harvey pointed out.

Most of them were made by the Germans before and during World War II and some of the German installations for production and study of nerve gases are in the eastern zone of Germany.

One of the more poisonous of the group is the nerve gas Drs. Harvey and Grob studied. Like the others, it is colorless, tasteless and without distinctive odor.

The volunteers all recovered completely from the moderate nerve gas poisoning they suffered as a result of small doses. When recovery from severe poisoning by the related, less poisonous chemical, parathion, took place, it also was complete.

The volunteers suffered symptoms ranging from slight eye pain, dimness of vision and headache to muscle cramps and general weakness of muscles, including the breathing muscles, giddiness, insomnia, nightmares, difficulty in concentrating and confusion.

Symptoms may start within a few minutes after exposure. Mild symptoms may last a few hours. Moderately severe ones may not reach their height for four to eight hours and usually grow less over a period of one to six days.

How long a man can live after exposure to nerve gas is not known. In accidental deaths from the less poisonous parathion, the average survival time after exposure was 10 and one-half hours. In some cases it was only one hour.

During the short time between exposure and death, doctors can do something. They can inject atropine, into the muscles for mild or moderate

symptoms, into the veins and in larger doses for severe symptoms. For prolonged convulsions, the epilepsy drug trimethadione or a barbiturate or ether may help. For breathing difficulty or arrest, artificial respiration must be given at once and may be needed continuously for hours.

Smoking should be avoided until the symptoms have subsided.

Atropine should not be given as a preventive before possible exposure because it may increase absorption of "nerve gas" through the lungs.

Persons once exposed to nerve gas are more susceptible to further exposure for several weeks.

A simple chemical test of the blood plasma and the red blood cells can be used to detect nerve gas poisoning in persons who may have been exposed and who have not developed enough symptoms for positive diagnosis. This test was developed by Dr. H. O. Michel of the Army Chemical Center, Edgewood, Md., and is now being used in factories making the related parathion and other insecticides.

The recommendations for diagnosis, treatment, and prevention through gas masks and protective clothing are based largely on experience in treating the moderate nerve gas symptoms in the volunteers, and severe poisoning in accidental exposure to parathion.

Anti-Cancer Cobalt Bomb

➤A NEW kind of cobalt bomb for cancer treatment is being readied for the Institute for Cancer Research and Lankenau Hospital Research Institute, Philadelphia. The new bomb will revolve around the patient instead of having the patient turned to get the cancer-killing rays from the radioactive cobalt.

Treatment time can be cut to 10 or 12 minutes per patient instead of a half hour and the patient can be made more comfortable during the treatment, Dr. Stanley P. Reimann pointed out to the American Medical Association.

Fish Gland Regulates Calcium

➤FISHES do have what corresponds to the parathyroid gland in higher animals for regulating calcium use, two American Museum of Natural History scientists have discovered.

Previously it was thought that calcium metabolism glands made their first evolutionary appearance in the amphibians (frogs, etc.), even though fishes lower on the scale of life admittedly were able to use calcium to build bones. The parathyroid function of bony fishes resides in their ultimobranchial gland, Priscilla Rasquin and Libby Rosenbloom reported to the American Society of Ichthyologists and Herpetologists. This was shown by experimentally produced hormone imbalance.

U. S. Settles Patent Claim For Atomic Fission Process

Fission Patent Case Settled

▶ THIRTEEN momentous years have passed since a group of Italian physicists received a patent, which had been five years in process of being granted, for a method of producing radioactive isotopes. It issued on July 2, 1940 as U.S. Patent No. 2,206,634.*

The inventors stated: "It is an object of the present invention to provide a method and apparatus by which nuclear reactions can be carried on with high efficiency and with the heavier as well as with the lighter elements.

"A more specific object of the invention is to provide a method and apparatus for artificially producing radio-active substances with efficiency such that their cost may be brought below that of natural radio-active materials.

"Our invention is based upon the use of neutrons instead of charged particles for the bombardment and transformation of the isotopes."

The latest chapter in the story of the fission patent is revealed in the following statement of the Atomic Energy Commission, released July 31 of this year:

Compensation Settlement

Payment of $300,000 as compensation for partial revocation of a patent granted to seven atomic scientists in 1940, and for infringing use by the U.S. Atomic Energy Commission and the Manhattan Engineer District, has been approved by the Commission and its Patent Compensation Board. The patent involved has been assigned to the U.S. Government.

The Patent, entitled "Process for the Production of Radioactive Substances," was granted on the basis of work by the seven scientists in Rome prior to 1934. One of the group was Enrico Fermi, who later played a leading role in the development of atomic energy in the United States during World War II.

Bruno Pontecorvo, who disappeared in September, 1950, after flying to Finland from England, and is believed to be in the Soviet Union, also was in the group. Pontecorvo originally held an eighth interest in the patent, but he assigned half of his interest to Eugene Ghiron-Fubini, Glen Head, Long Island, New York, in October, 1942. Pontecorvo gave his power of attorney to the attorney for the applicants before his disappearance.

The one-sixteenth share still assigned to Pontecorvo will be deposited in the U.S. Treasury pursuant to Treasury Departmental Circular No. 655, which governs the payment of funds to individuals in certain countries.

The other scientists who had an interest in the patent are Edoardo Amaldi, Istituto fisico della Universita, Rome; Oscar a'Agostino, Isti-

* This patent was reprinted as a "Classic of Chemistry" in Atomic Facts, published by Science Service, Washington, 1950.

tuto di Sanita Pubblica, Rome; Franco Rasetti, Johns Hopkins University, Baltimore; Emilio Segre, Berkeley, California, and Guilio Cesare Trabacchi, Istituto di Sanita Pubblica, Rome. Each of them, along with Fermi, held an eighth interest. G. M. Giannini and Co., Inc., of Pasadena, assignee and legal owner of the patent, also held an eighth interest.

The discovery involved in the patent was that radioactive isotopes of a number of elements can be produced by exposing the elements to neutrons which have been slowed down by passage through a moderating material. This principle has been applied in the atomic energy program.

The patent, granted in 1940, was partially revoked under provisions of Sections 11 (a) (2) and 11 (b) of the Atomic Energy Act of 1946. These sections revoke any patent to the extent that the invention or discovery involved is used in the production of fissionable material or in the utilization of fissionable material or atomic energy for a military weapon, or in research or development activities in these fields. The Act provides that "just compensation" shall be made for such revocation.

The settlement stipulation and agreement entered into between AEC and the Giannini Co. included settlement of all claims, including that of infringement, and provided for an assignment to all right, title and interest in and to the patent to the Government, as represented by the Commission.

In 1948, the Giannini Co. filed an application before the Commission's Patent Compensation Board for $1,900,000 as just compensation and reasonable royalty for partial revocation of the patent. Another application for $2,100,000 was filed in July, 1952. The company also had filed an action in the Court of Claims for $10,000,000, which was withdrawn before the settlement.

Rice Oil Helps Cooks and Industry

▶ CHEMISTS have learned to extract a new oil from rice bran which is usually wasted in the milling of rice. The oil promises to be a boon to housewives and to manufacturers of cosmetics, soaps and anti-rust compounds.

Pioneered by the American Rice Growers' Cooperative Association, Houston, Texas, the new industrial extraction process yields a clear, light-colored oil having a bland flavor and odor. It resembles peanut oil in physical properties, but is more resistant to becoming rancid than other vegetable oils.

Rice oil when used in cooking does not pick up flavors and odors of foods fried in it. Thus the housewife can fry fish, potatoes, onions, chicken and oysters in it without the problem of carry-over flavor. Foods fried in rice oil also contain less fat than when they are fried in other oils.

Further experiments have shown that the oil also is a good industrial lubricant because of its high penetration ability. A by-product of the oil is rice-bran wax which has a melting point as high as carnauba wax.

Explosion, Boiling and Freezing Begin at Separate, Discrete Points

The Starting Point

Reprinted from the Industrial Bulletin of Arthur D. Little, Inc.

IN THE chemical and physical world, as in human affairs, large changes usually start from small beginnings. If a substance explodes, breaks, crystallizes, boils, or condenses, the process usually does not start everywhere at once, but begins in a small way at one or more centers. This starting of chemical or physical changes at discrete points is something called "nucleation."

Study of nucleation is a precise science, although is usually deals not with ideal events, but with the way things happen in the confusion of the everyday world. Thus it links the empirical knowledge of the "cookbook" artisan with the theory of the physicist, and leads to both better theory and better "cooking." For example, even if a substance or a system is in an unstable state (e.g., a liquid cooler than its freezing temperature), it may not spontaneously shift over to a stable state (solid). Nucleation theory shows that formation of an organized surface, as when ice forms in water, requires some extra energy at the point of formation, even though the mass of water gives up energy (heat) when it changes from liquid to solid.

Nucleation may be divided into two classes. In "homogeneous" nucleation, the unstable state is so very unstable (e.g., so far below its freezing point, although still a liquid) that some portion of it happens to shift over to the stable state spontaneously. In "heterogeneous" nucleation, a suitable starting surface is provided from outside the system, or occurs as an impurity; thus the extra energy usually required to form the surface is small and a good part of the energy necessary to start the new phase is provided by the extraneous particles themselves. For example, ordinary molten tin metal in bulk begins to freeze into crystals at only a few degrees below its melting point of 450°F. This happens because of various solid impurities which are present, and which serve as nuclei for crystal formation. The number, size, and even the structure of the crystals in the solid metal are determined by the number and kind of centers, or nuclei, from which the crystals grow. If molten tin is carefully purified, however, and subdivided into many small droplets, most of these drops do not freeze until the temperature is about 233°F., over 200° below the melting point. In this case, there are no impurities on which crystals can form, and the tin does not freeze until it is supercooled to such an extent that crystals form spontaneously without the need of foreign nuclei.

It is becoming increasingly apparent that nucleation phenomena play an important role in what at first might appear to be unrelated processes. The formation of clouds and smoke and

the latent photographic image are all nucleation phenomena. Whether or not condensation occurs in steam turbines or supersonic wind tunnels, and where, depends on the formation of nuclei for condensation. Many of the principles of nucleation control were in use long before anyone gave any thought to the process. For example, uncalcined gypsum added to plaster of Paris has long been known to accelerate setting of the plaster; churning ice cream or beating fudge promotes the formation of many fine crystals. The scratching of a piece of glass to cause it to break is another example of "nucleating" a phase change.

The systematic investigation of the condensation of moisture to form drops in clouds, around the turn of the century, was the beginning of the scientific approach to nucleation. These studies led to development of the Wilson cloud chamber, in which the ions produced by high-energy particles are made visible by the fact that they serve as nuclei for the condensation of droplets. The aspect of nucleation which has attracted the most wide-spread public interest, however, is its application to the weather. By causing ice crystals to form in supercooled clouds, using either dry ice or silver iodide, it is now definitely possible to cause more or less controlled formation of snow or rain.

Promising applications of nucleation theory are looked for in such diverse areas as the devitrification of glass, the control of ice formation in hydroelectric plants, and study of the incidence of cancer. As the theory is extended and applied, it appears probable that nucleation principles will find new areas of usefulness and bring into the realm of science many processes which are still arts.

Why Do Avocados Ripen?

➤ A MATURE avocado may stay firm and unripened on the tree for many months. Why then, does it begin to ripen as soon as it is harvested?

This is a question Dr. Jacob Biale and Roy Young of the University of California at Los Angeles' subtropical horticulture laboratory are seeking to answer.

New techniques which enable the scientists to isolate cytoplasmic particles (certain parts of a cell) of the fruit have revealed new clues as to the nature of the chemical process involved in ripening.

Key to the process may be phosphorus, an important chemical in all life processes, Dr. Biale said. Ripening may occur when phosphorus is converted from the inorganic state to an organic state by combining with certain sugars. The organic phosphorus compounds formed are high energy phosphates.

The fruit also changes its respiration rate during ripening as "burning" of the sugars involved in the chemical reactions requires more oxygen. Increased oxygen consumption can be measured by sensitive laboratory devices.

Just what triggers the chemical action when the fruit is pulled from the tree is something future research may reveal.

Chemical Reduction Process Revolutionizes Ore Reduction

Ideas for Continued Progress

Reprinted from For Instance, *American Cyanamid Co.*

MATERIAL and cultural progress depends on the conception of new ideas and their application to human affairs. Today the rate of progress is phenomenal because good ideas are being conceived and put to work with amazing frequency. A few years ago an idea was brought forth which bids fair to revolutionize certain metallurgical processes that have been established for centuries. Metals have always been produced from ores by a smelting or heat reduction process. Now, large scale construction is under way to produce copper, nickel and cobalt by a chemical reduction process.

Under the high temperature conditions which existed just prior to the solidification of the earth's crust most metals were combined with sulfur or oxygen to form sulfide and oxide minerals. These were concentrated in the molten siliceous material which forms the rocks in certain regions of the earth's crust. The principal copper ores are sulfides but sometimes they contain as little as 0.8% copper or only 16 pounds of copper per ton of rock. It would be economically impossible to treat these ores but for the froth flotation process which efficiently sorts out the valuable minerals from the mass of ground rock. During World War II one large company processed as much as 100,000 tons of low grade ore per day and obtained a concentrate containing about 30% copper. In the heat reduction process the concentrate is "roasted" to control its sulfur content, "smelted" to separate the metal sulfides from the siliceous slag, "converted" by blowing air through the molten mass to oxidize the remaining sulfur and obtain crude or "blister" copper, then "refined" to eliminate traces of other metals and combined oxygen. Except for tremendous improvements in technique this is basically the same method to reduce copper from its ore as used by the earliest craftsmen almost 6,000 years ago.

The new chemical reduction process starts with the concentrate but mixes it with water to form a slurry. This is pumped into a continuous reactor, stirred violently, and air blown into it under high pressure. Under these conditions the oxygen (O_2) of the air combines with the insoluble copper sulfide (CuS) to form the soluble copper sulfate ($CuSO_4$). The mass is filtered to obtain the $CuSO_4$ solution. Hydrogen gas (H_2) is forced into this solution in another reactor and you have probably guessed what the result will be; pure copper (Cu) is obtained and sulfuric acid (H_2SO_4) is a by-product. The acid may be reacted with ammonia to produce the fertilizer, ammonium sulfate. Of course, this is a highly simplified version, but most of our problems may be presented in less complex terms after the answers have been diligently worked out.

Typical of chemical processes many variations are possible, and excellent results have been obtained with the ores of various metals. One relatively small plant will boost the world output of strategic cobalt at least 40%. Another under construction is designed for 8,500 tons of nickel, 1,000 tons of copper and 150 tons of cobalt, plus 70,000 tons of ammonium sulfate annually. Ultimately, the process may be adjusted for the production of some of the lower priced metals. The economies of the process are such that in some cases, existing smelting facilities may be scrapped and the conversion costs made up in a few years. The chemical reduction plants are so compact and efficient that they may be built at the mine site thus saving transportation costs of ore or concentrates, and eliminating the time lag between mining the ore and producing the metal.

The history of this development is another excellent example of cooperation for achievement. The basic idea was obtained through astute observation of an unusual phenomenon connected with a chemical process. Could this be applied to metal production? The achievement was accomplished by cooperation with those having experience in metallurgical engineering and chemical plant construction.

The ultimate result from the development of a drastically new idea may be very far reaching. When gunpowder was made available feudal barons could no longer maintain their isolation so the power of the modern state was born. Subsequent industrial developments delineated its pattern and continue to shape its course. The mariner's compass opened the vast stretches of ocean to navigation and made possible the discovery of new worlds. The telescope permitted man to see farther, but it also revealed that the earth is not the center of the universe and full realization of this fact changed man's philosophy of life. These are just a few examples of the power of thought expressed as id as and applied to the affairs of man; truly, "as a man thinketh so is he."

Light-Sensitive Plastics for Photographs

➤ PLASTICS can be made into photographic material, S. B. Elliott of the Ferro Chemical Corp., Bedford, Ohio, told the Society of Photographic Engineers recently.

Small quantities of halogenated compounds unstable to actinic light are incorporated into various plastics. Among the plastics that can be treated in this way are polyvinyl chlorides, polyvinylidene chloride, cellulose acetate, ethyl cellulose and other materials.

The photosensitive compounds evolve hydrogen halides upon exposure to light and active catalysts are formed if certain metal compounds are present. These in turn degrade the plastic and make possible the formation of images.

New applications of photography through this use of plastics are foreseen as the result of this research.

Germs Resisting Miracle Drugs Breed Epidemics

Diseases From Resistant Germs

➤ THE SPECTER of man-made epidemics of disease is haunting some of the medical scientists. It is not bacteriological, or germ, warfare by an enemy power they are talking about. It is the peril of new races of germs coming to the fore through a man-made instead of a natural process of selection.

Our modern, so-called miracle drugs, from penicillin to isoniazid, are doing this selection. As they save lives from mastoid infection, pneumonia and tuberculosis, to name only a few, they are creating new disease threats. Already the staphylococcus population in the United States has changed. Since 1943 when penicillin first was used to fight these germ causes of boils, some pneumonias and blood poisonings, they have mutated into a race almost entirely resistant to penicillin.

Resistance of germs to antibiotics and the new TB remedy, isoniazid, does not come from contact with the drugs, Dr. Vernon Bryson of the Biological Laboratory, Cold Spring Harbor, N.Y., declares.

Some germs are genetically constituted to resist antibiotics, just as some people are genetically constituted to have blue eyes or curly hair. The gene responsible for drug resistance can be located in the bacteria cell. The drugs come into the picture because when they kill the non-resistant germs, the ones with resistance bred in them by natural processes can persist and breed more of their kind.

Drug manufacturers realize that they cannot keep up with the resistant germs by making new and yet newer antibiotics.

Two answers to the problems, one of them with a possible answer to the cancer problem as well, are given by Dr. Bryson and Dr. Edward J. Grace, chest surgeon and TB specialist of the Grace Clinic, Brooklyn, N.Y.

One answer Dr. Grace has already been using successfully. It is to wage total war on TB or any other infection by giving the patient at the beginning large doses of antibiotics and giving them by every possible route.

For tuberculosis patients this means giving streptomycin, PAS and isoniazid together. The three are injected, PAS is given by mouth and, most important in lung infections, the drugs are given dissolved in a detergent by inhalation.

When the patient breathes this drug-filled vapor deeply into his lungs, the drugs get at the seat of the infection. After all, Dr. Grace pointed out, the TB germs are in the lungs, not the buttocks where streptomycin and isoniazid are usually injected. And when the patient breathes the antibiotic mist deeply enough, the drugs get through the lungs and into the blood stream in amounts large enough to be remedial.

Of 14 patients given this all-out treatment in the office, without having to be in hospitals, 12 were cured within eight to 12 months.

Second answer to the problem will come when scientists can develop a new kind of antibiotic, which Dr. Bryson calls an antimutagenic. Such chemicals, Dr. Bryson said, will tend to decrease the hereditary variability of microorganisms, stopping their tendency to mutate into drug resistant forms. Antimutagenics might also, theoretically, reduce the tendency of human body cells to mutate into cancer cells. One such antimutagenic chemical has been found by Drs. L. Szilard and A. Novick of the University of Chicago. It is adenosine, a constituent of the nuclear protein of cells and will decrease hereditary mutation of cells to some extent.

Meanwhile Dr. Grace urges fellow physicians to use antibiotics intelligently and in combination to postpone the origin of resistant germs.

"It's Henry's *last stand against the crab grass!*"

For The Home Lab

Phenol

by BURTON L. HAWK

THE VERY important phenol, or carbolic acid, is present in coal tar. In fact, it was originally obtained from coal tar. But it became so useful in the preparation of medical and industrial compounds, dyes, and resins that the coal-tar supply was no longer adequate. So the chemist had to devise other means of producing the compound.

The technical definition of a phenol is "a derivative of benzene which contains one or more hydroxyl groups (OH) attached directly to carbon atoms of the nucleus." Thus, we have the formula of benzene as C_6H_6. Replacing one hydrogen with one hydroxyl group, we have a monohydroxybenzene, C_6H_5OH, which we know as phenol. Using two hydroxyl groups, we obtain dihydroxybenzenes, such as *catechol*, $C_6H_4(OH)_2$; *resorcinol*, *m*-$C_6H_4(OH)_2$; and *hydroquinone*, *p*-$C_6H_4(OH)_2$. Or, replacing with three hydroxyl groups we have *pyrogallol*, 1-2-3-$C_6H_3(OH)_3$; *phloroglucinol*, 1-3-5-$C_6H_3(OH)_3$; and *hydroxyquinol*, 1-2-4-$C_6H_3(OH)_3$.

It would appear from the above that the logical compound to use in the preparation of phenol would be benzene. And so it is used. In one process the benzene is sulfonated to obtain benzenesulfonic acid, which in turn is converted to the sodium salt. The sodium benzene-sulfonate is treated with molten sodium hydroxide to obtain sodium phenoxide. The phenol is liberated from the phenoxide by carbon dioxide or sulfur dioxide.

In another process (the Dow process) the benzene is chlorinated to form chlorobenzene. This compound is mixed with diphenyl oxide and sodium carbonate and subjected to heat and pressure to obtain the phenol.

Still another process converts chlorobenzene to phenol by forcing it with steam over a silica gel preparation at high temperatures.

In the laboratory, it is most convenient to prepare phenol from aniline by a process of diazotization followed by hydrolysis. As you know, the aniline itself is obtained from nitrobenzene which in turn is prepared from benzene.

First it is necessary to convert the aniline to the sulfate. Place 40 cc. of water in a beaker. Slowly add 6 cc. of sulfuric acid. Stir the solution, and while still warm, add 5 grams of aniline. Continue stirring until the aniline sulfate dissolves and a clear solution is obtained. If necessary, warm the solution gently.

Bring the temperature of the solution down to 5 degrees by immersing the beaker in a mixture of cracked ice and salt. Dissolve 4 grams of sodium nitrite in a small quantity of water and add it slowly to the cooled aniline sulfate solution. Add only a small quantity at a time, stirring after each

addition. You should allow about ten minutes to complete this reaction. This process is known as *diazotization*, and the compound obtained is benzene diazonium sulfate. Whenever you experiment with diazotization reactions, be sure to follow instructions carefully. These compounds are tricky, and in the dry state there is some danger of explosion.

After all the nitrite has been added, allow the beaker to remain in the ice bath for about five minutes. Then transfer the liquid to a large flask. Heat gently to a temperature of 50 degrees. At this point nitrogen is evolved and the reaction should proceed of itself without further heating. During this reaction the phenol separates as a dark-colored oil. After all action ceases, carefully draw off the oil with a medicine dropper. This is crude phenol.

Dissolve as much of the oil as possible in water by boiling and stirring rapidly. Add some of the solution to a solution of ferric chloride. A violet coloration is obtained which identifies the phenol.

Mix a small quantity of phenol solution with hydrochloric acid and add a few drops of concentrated nitric acid. A red color is formed.

Add a few crystals of sodium nitrite to phenol solution along with a solution of mercurous nitrate. Boil for a short time. A red color is obtained. This is an extremely sensitive test for phenol.

Dissolve a crystal of sodium nitrite in 3 cc. of concentrated sulfuric acid. Add a small quantity of phenol (about ½ gram). A brown solution is obtained at first which quickly changes to blue. If you pour this liquid into water, it will turn red. If you add sodium hydroxide solution it will turn greenish-blue.

Phenol Resins

Phenol is used in the manufacture of various resins and plastics. With formaldehyde, it forms the popular *Bakelite*. You can prepare several of these resins in the home laboratory, but we suggest you use purified crystals of phenol rather than the crude oil obtained in the experiment. You can, of course, purify the oil if you wish by a process of steam distillation. The distillate is saturated with salt and the phenol extracted with ether. This is a rather elaborate operation not too well suited for a home laboratory.

Bakelite can be prepared by heating a mixture of 3 grams phenol, 6 cc. of formaldehyde and 10 drops of sodium hydroxide solution in a flask. Apply an even steady heat until a thick molasses-like consistency is obtained. Remove from the flame and pour into a test tube which will serve as a mold. The gummy mass is hardened by baking in an oven for about three hours at a temperature of 60 to 75 degrees C.

Another resin can be obtained by using hexamethylene tetramine, which is a compound made from formaldehyde. Mix 3 grams of phenol with ½ gram of hexamethylene tetramine. Warm the mixture very slowly until complete solution of the compounds is obtained. Then heat to 150 degrees, at which time ammonia is formed. Remove the heat and allow the action to proceed by itself. After all action ceases, allow to cool. The plastic obtained can be worked into any shape desired before it hardens.

Where the Elements Appear In Analytical Separations

Analyzing For All the Elements

Group I, a and b

▶ Analysis of minerals is becoming popular again, after being neglected for a number of years. Search for uranium and other unusual metals has stimulated interest in qualitative analysis. But many text books designed for school use limit their scope to analysis of a selection of metals and acids which illustrate principles of analysis. No provision is made in these texts for other elements, some of which might be present in rock samples.

The series starting here aims to indicate the analytical groups into which compounds of all the elements would fall. The reactions are those recorded in the literature, and no claim is made for compilation of a complete course in analytical methods. The reactions are offered merely as an exercise in handling compounds in each Group of the Periodic Table.

Starting with Group I, *a* and *b*, in this issue, the series is planned to give analytical reactions characteristic of the elements in each of the eight Groups of the Table (exclusive of the inert elements). It will run through the eight issues of the coming school year.

The qualitative scheme of analysis is based on a series of reactions, mostly caused by addition of the sulfide ion, to a solution in which several metallic ions are present together. Addition of a reagent causes the separation of groups of these metals as insoluble precipitates.

These are filtered off, leaving others in solution. The precipitates are dissolved in appropriate acid or alkaline solvents, further separations are accomplished, and finally the individual elements are identified. The filtrates are treated with other reagents, other elements are precipitated, and these in turn identified, until all the possibilities of the "unknown" are exhausted.

An unknown mineral, salt or other inorganic compound must first be brought into solution, to use this scheme. Solution in nitric acid is preferred for starting the analysis. If this cannot be accomplished, the material is fused with any one of a number of fluxes, and the resulting melt extracted with water or acids. There are many excellent manuals of qualitative analysis, which give details of procedures for all the common elements.

The first step after getting the material into nitric acid solution is to test part of the solution with hydrochloric acid for the presence of the only three metals which form insoluble chlorides: silver, lead and mercurous mercury.

Metals of the Alkali Group form very few insoluble compounds. Their presence is usually determined by flame tests and spectroscopic examination of a portion of the original sample, after the presence or absence

of other elements has been established. Alkaline Earths, including magnesium but not beryllium, form insoluble carbonates. This reaction is usually depended upon for recognition of this class, with flame tests to determine which metal is present.

The great bulk of metallic elements are precipitated by hydrogen sulfide. From acid solution, H_2S throws down sulfides of many metals, such as copper, lead, cadmium, and bismuth, and of another array of elements, including tin, arsenic, antimony and mercuric mercury, which can be separated from the first group by dissolving them in alkaline solutions.

Other metals separated by hydrogen sulfide come down when the filtrate from the acid precipitation is made alkaline with ammonium hydroxide and more hydrogen sulfide is added. This precipitate is composed of a mixture of sulfides and hydroxides. Aluminum and zinc are characteristic elements separated in this way, but ammonium hydroxide also separates the lanthanide and actinide elements and many others. These "rare earth" series elements present very special problems in analysis, and if they are present in large quantity the student should refer to one of the newer works dealing especially with them. (Analytical Chemistry of the Manhattan Project, Rodden, National Nuclear Energy Series, McGraw-Hill, 1950, is recommended.)

After precipitation of the Ammonium Sulfide Group of elements, mentioned above, the precipitate is dissolved in hydrochloric acid, and separated by addition of sodium hydroxide. The techniques vary somewhat according to the presence or absence of iron and other troublesome metals, but the succession of precipitates from acid, neutral and alkaline solutions should be kept in mind.

Ia. Alkali Metals in the Analytical Scheme

	HCL	H_2S	$(NH_4)_2S$	$(NH_4)_2CO_3$	Special test
Li	—	—	—	—	Red flame
Na	—	—	—	—	Yellow flame
K	—	—	—	—	Violet flame
Rb	—	—	—	—	Reddish-violet flame, red spectrum line
Cs	—	—	—	—	Reddish-violet flame, blue spectrum line
Fr	—	—	—	—	Radioactive period 21 minutes

Lithium forms a precipitate with hydrogen sodium phosphate solution, but does not form a precipitate with hydrochloroplatinic acid. Lithium compounds are generally soluble in alcohol. The red flame color and the characteristic spectrum generally confirm the presence of lithium. Many compounds of lithium are commercially available, in the price range of $1.00 to $2.00 per pound in quantity lots.

Sodium compounds are so universally present that the yellow color

they give to the colorless flame of the Bunsen burner is very familiar. It is scarcely a definite test, for it masks many weaker or more fleeting flame colors. Since most sodium compounds are soluble, only a few complex groups combine with sodium to form a precipitate. Some of those most used for the purpose are the uranyl acetates of magnesium and of zinc. An older reagent is acid potassium pyroantimonate. In the spectroscope, the double line in the yellow part of the sodium spectrum is one of the reference standards.

Potassium may be determined by its flame in the presence of sodium by looking at the flame through a thick piece of cobalt glass, which absorbs the yellow color and allows the violet potassium flame to shine through. Hydrochloroplatinic acid gives a precipitate from concentrated solutions containing potassium, but the corresponding ammonium salt will form if ammonium ions are present. The same objection applies to the use of tartaric acid and of hydrogen sodium tartrate. Potassium may also be precipitated as the perchlorate and as the cobaltinitrite. Sodium cobaltinitrite is said to be somewhat unreliable for very exact work, and silver cobaltinitrite is sometimes used in its place.

Rubidium and *cesium* are widely dispersed in nature, in very small quantities. Cesium is used commercially as a "getter" to remove small quantities of gas from vacuum apparatus. The two elements are best recognized by their spectra. They react, in general, in the same way as potassium. Cesium, however, may be separated from rubidium and potassium by treatment with stannic chloride or with antimonious chloride. The antimony salt will separate it from ammonium compounds and from all the other alkali elements. With stannic chloride, ammonuim compounds will precipitate along with the cesium ones. The similarity of ammonium compounds to those of the alkali metals used to be considered quite mysterious, but has now been traced to similarity of electron structure of their ions. Potassium and rubidium each have a radioactive isotope occurring naturally: $_{19}K^{40}$, half-life 2.4 x 10^8 yr., and $_{37}Rb^{87}$, half-life 6.3 x 10^{10} yr.

Cesium and rubidium compounds are on the market, as well as cesium metal. The salts must be handled carefully and kept in tightly closed containers. The metal, like sodium and potassium, must be kept under mineral oil to prevent reaction with air and moisture with consequent fire risk.

Francium, heaviest and most alkaline of the alkali metals, was found by Mlle. Marguerite Perey in 1939 as a disintegration product of actinium. She recognized it as a previously unknown radioactivity persisting in the solution from which all other known elements had been eliminated in the course of analysis. Assuming from the evidence that the previously unknown element No. 87, homologue of cesium, must be present, she added cesium chloride to the solution and precipitated it with sodium perchlorate. The activity, which had previously remained in the filtrate throughout the analytical procedure, was found in the precipitate of cesium perchlorate, proving that the new element, present in invisible amount, was indeed the missing element of Group I*a*.

Ib. Noble Metals

	HCL	H_2S	$(NH_4)_2S$	$(NH_4)_2CO_3$	Special test
Cu	—	CuS	—	—	Blue color of compounds. Precipitation of reddish cupric ferrocyanide.
Ag	AgCl	—	—	—	AgCl turns dark on exposure to sunlight.
Au	—	Au_2S_2	—	—	Gold forms few compounds, which are reduced to metal before the blowpipe. The metal dissolves in aqua regia.

Copper is precipitated as the black sulfide from acid solution. When the precipitates caused by hydrogen sulfide in acid solution are treated with an alkaline solution containing sulfur, such as potassium hydrogen sulfide, copper sulfide remains undissolved, along with the sulfides of lead, bismuth and cadmium. They are thus separated from the sulfides of mercury, arsenic, antimony and tin, which dissolve in the reagent. The sulfides insoluble in potassium hydrogen sulfide are dissolved in nitric acid. Adding sulfuric acid and boiling off the nitric removes the lead as sulfate. Addition of excess ammonia to the filtrate allows the bismuth to come down as the hydroxide, leaving cadmium and copper in solution. A quantity of copper will probably be recognized here by the blue color of the solution. To precipitate the cadmium but not the copper, add potassium cyanide solution slowly until the blue color disappears. Precipitate the bright yellow cadmium sulfide from the decolorized alkaline solution with H_2S.

Silver is one of the three metals which form insoluble chlorides. It is easily detected at the beginning of the course of analysis by addition of hydrochloric acid to the solution of the material to be analyzed. The other elements showing this property are lead, whose white chloride can be dissolved in hot water, and mercury in its lower valence state, whose chloride is also white, but insoluble in hot water and also in ammonia solution. Silver chloride dissolves in ammonia solution, leaving the mercurous chloride, which proceeds to turn black, because the ammonia has reduced part of it to the metal. From the ammoniacal solution, silver chloride can be recovered by addition of hydrochloric acid. Sunlight will darken silver chloride, the reaction upon which photography is founded. The appearance of the two blackening reactions (silver and mercury) is characteristically different.

Gold, if present in the solution being analyzed, will precipitate as sulfide in the same reactions as copper. Gold sulfide is soluble in potassium sulfide and in an excess of ammonium sulfide. It can be reduced to the metal before the blow-pipe, and is recognized by its unique color. With stannous chloride and a little chlorine water, in dilute solution, gold produces the violet coloration known as "Purple of Cassius."

Some of the Problems Of Our AEC Installations

Atomic Energy as an Industry

An extract from an address by Capt. J. T. Hayward, USN, Chief of the Weapons Research Branch, Division of Military Application, United States Atomic Energy Commission, before the Wings Club, at New York.

▶ First, let us take a quick look at what we operate and manage.

We will begin with real estate. The AEC has jurisdiction over more than 3,200 square miles of land. That is equal to the combined area of two states—Delaware and Rhode Island.

This realty includes such varied holdings as rented rooms of office buildings, three modern cities with a combined population of 70,000; a carefully preserved sacred Indian cemetery, two 600-square-mile atolls 4,500 miles out in the Pacific Ocean. During continental tests, we rent the back yard and part of the kitchen of a home on the outskirts of Las Vegas, Nevada, for measuring shock waves, and the roofs of small hotels and garages in scattered Southwestern towns on which we put equipment used in monitoring radiation.

Physical Plant: The permanent assets of the AEC in the form of plants and equipment total more than three and a half billion and are being added to at a rapid rate in the current expanding program. Its variety is almost infinite. I will pick out a few items:

Buildings from the Chic Sale type of sanitary equipment to one of the world's largest plants under one roof —the mile-long four-story concrete gaseous diffusion plant at Oak Ridge, Tennessee. Equipment from quartz wire so small as to be almost invisible to the eye and fascinating doll-size utensils used in the microchemistry to the huge concrete "canyons" at Hanford. There, technicians working in the lead shielded cubicles of huge cranes use periscopes to handle the witches' brew of fission products that seethes 50 feet below them. In transportation: From bicycles, which meter readers use to save time and footleather at the vast U-235 plant at Oak Ridge to a railroad complete with seven Diesel engines and a classification yard at Hanford. In optics: From mirrors in washrooms to three-dimensional television. In photography: We use practically every type of camera that is on the market and have taken equipment made in Rochester and run it at speeds from 500 to 15,000 frames per second. This should give you an idea of the complexity of the AEC inventory.

Personnel: Employment in the national atomic energy program is increasing due to the tremendous building program. Even before this got underway, payrolls of the AEC construction firms represented three per cent of the total national contract construction employment.

There are about 150,000 persons currently working on atomic energy projects. This includes only the personnel of our construction and operating contractors and the AEC itself.

It has been estimated that several hundred thousand more are indirectly employed by firms that render services or furnish supplies to the agency. This last statement may interest some of you here.

Construction accounts for 80,000 of the total of 147,000 employees as of October. The operating contractors employ more than 61,000. That leaves less than 7,000 employed directly by the AEC, or about 4% of the total.

Construction: Again, the key word for understanding is variety. We have two prime contracts for more than a billion dollars—with duPont to build the Savannah River Plant and with the Peter Kiewit Sons to construct the $1.2 billion plant in Southern Ohio. Going down to the other end of the scale, our maintenance contractors at the atomic cities have to do ordinary home repairs on government-owned apartments, dormitories and houses.

Contracts: More than 5,000 firms hold or have held prime contracts with the AEC. The roster reads like a list of the blue chip industrial organizations in our nation. I have time to name only a few: Union Carbide and Carbon, General Electric, Westinghouse, duPont, Tennessee Eastman, Monsanto Chemical, Dow Chemical, Proctor and Gamble, American Cyanamid, National Lead, Phillips Petroleum, several members of the Standard Oil group, and—in the latest major addition—the Goodyear Tire and Rubber Company, which has contracted to run the new U-235 plant being built in Ohio.

Last year (fiscal 1952), AEC awarded nearly 18,000 prime contracts and purchase orders. Our cost type contractors in turn let more than 375,000 subcontracts and purchase orders. And remember, it is our duty to see that the taxpayer is getting his money's worth on each of these tens of thousands of contracts.

How do we do it? I am not going to go into details of the organization chart. Five commissioners, nominated by the President for staggered five-year terms and requiring Senate confirmation, make the top governing body. They report to several committees in Congress.

The first is the 18-man Joint Committee on Atomic Energy, created by the McMahon Act and whose first chairman was the late Senator Brien McMahon of Connecticut. There is close liaison between the AEC and the JCC, as we call it, the latter is empowered to make continuing studies of problems relating to the development, use and control of atomic energy. Congress also looks to the JCC to keep it informed of major activities and problems of the AEC.

The other committees are those before which all Federal agencies must stand in judgment at least once a year —the Senate and House Appropriations Committees. The AEC is under the particular scrutiny of the Subcommittees on Independent Offices.

There are two other committees set up in the Atomic Energy Act. The first is a General Advisory Committee, named by the President and is composed of top flight scientific, engineering and industrial leaders. Since sources of informed criticism of our operations are few, the GAC has performed a valuable function in this respect. It has averaged six meetings a year and up to now has been headed by the man often dubbed "Mr. Atom,"

▶ THE CONSOLE *at which the operator of the nuclear reactor plays atomic harmonies. Here the controls were manipulated when the Oak Ridge experimental homogeneous reactor, operated for the Atomic Energy Commission by Union Carbide and Carbon Corporation, began to produce usable atomic energy, in February 1953.*

—Dr. J. Robert Oppenheimer, who has retired from the GAC after valuable and constructive service.

The other statutory committee is the Military Liaison Committee consisting of representatives of the Armed Forces in number determined by the Secretary of Defense. Its title accurately describes its function. If it disagrees with the AEC over policy which affects the armed forces, it can make recommendations to the Secretary of Defense with the latter taking the matter to the President if he sees fit.

Obviously, there have been from time to time differences of opinion between the AEC and this or that segment of the armed forces. But they have been settled amicably as the cordial expressions in the annual reports of the Secretary of Defense testify.

The chief operating post in the AEC

➤ AT THE TOP *of the shield, heavy concrete plugs can be lifted to give access to the reactor which is surrounded by this wall of concrete blocks. This is the experimental homogeneous reactor run by Carbide for the A.E.C.*

▶ FIRST LIGHT *from the experimental homogeneous reactor at Oak Ridge illuminates the group of men responsible for obtaining this electric output of the atomic furnace. All are members of the technical staff of Union Carbide and Carbon Corporation, which operates this A.E.C. Laboratory.*

is the General Manager, now held by the genial Marion W. Boyer, who had a brilliant career as a production executive with the Standard Oil of Louisiana. It is a back-breaking job. Originally, all the division heads and managers of operations in the field reported directly to the General Manager. As the program became more complex, it was found necessary to relieve the General Manager of some of his workload. So, the major activities in the field were grouped along functional lines under the various program division directors.

It also has been found necessary to give the General Manager a deputy and several assistants and to attach several vital functions directly to his office. There is the Office of Intelligence, which works closely with other government intelligence offices. Then there is the unit which our public information men deal with the most—the Office of Classification. It advises the Commission on the status of ma-

terial defined in the law as "restricted data." It maintains various guides which it uses in providing detailed security review to both the public and technical information staffs. The Office of Classification is assisted by a capable group of scientists and engineers scattered over the country who are called Senior Reviewers.

There are twelve major divisions, evenly divided (coincidently) between operations and staff functions. Most of their names are self-explanatory: The *Operating Divisions* are: Military Application, Production (this includes responsibility for the output of fissionable materials); Raw Materials; Reactor Development (responsible for the development of atomic power); Research; and Biology and Medicine. The staff divisions are the usual ones —Legal, Finance, Information, Organization and Personnel, Construction and Supply, plus the important Division of Security.

One outstanding and successful principle of AEC management has been delegation of responsibility with authority commensurate with the functions assigned and decentralization of operations away from Washington.

There are ten major Operations Offices, each headed by a manager, scattered over the country. I've mentioned the two in your state—in New York City and at Schenectady. Others are headquartered near Chicago; Oak Ridge, Tennessee; Augusta, Georgia; Richland, Washington; Idaho Falls, Idaho; Albuquerque, New Mexico; San Francisco, California; and Grand Junction, Colorado. Several of these have sub-offices headed by area managers.

Each Operations office is an integrated organization, practically self-sufficient and handling the rather extensive business operations involved and a considerable measure of technical supervision of the activities in its area. Operations managers have authority to let contracts, without approval by Washington, of from $1,000,000 to $5,000,000 depending on the type and size of the installation.

Several factors have contributed toward some increase in centralization of authority in Washington. Congress has been giving more attention to details of operations and this has required that a bigger volume of current information be on tap in Washington. The increasing geographical dispersion and diversity of projects has necessitated closer over-all supervision to forestall overlapping or duplication. The increasing urgency of the time schedule demands the closest integration of the program from ore buying to finished products. The growing impact of the AEC activities on those of other Federal agencies has required more direct action in Washington. Despite this, the basic operating format of decentralized operation and authority still prevails to a large extent.

One of the first decisions made by the Commission was to continue the MED policy of contracting all possible work to industrial and academic contractors rather than change to direct government operation. The first AEC General Manager Carroll L. Wilson summarized the reasons for the decisions as follows:

"There was room (under the contract system) for innovation, for experiment, for trial of different ways of performing these many functions. . . . In addition, it was recognized that if atomic energy were to become a generic part of the American scene, it should have its roots deep in the institutions which are so productive a part of American progress in science and technology."

I think it no exaggeration to say that without this harnessing of the academic skills and the matchless industrial potential of our country, through the contract system, the national atomic energy program would not be in the advanced and healthy condition we believe it to be today.

Another excellent aid to AEC management is the practice of going outside both the Commission and its contractors for advice and assistance. Our last report to Congress lists 17 committees—and some of them date back to the first year of AEC operations—that have been formed to bring to the AEC a fresh approach or a continuing outside review of some aspect of our work. Merely naming a few of them will give you an idea of the kind of assistance we seek:

Industrial Committee on Reactor Location Problems; Advisory Committee on Biology and Medicine; Patent Advisory Board; Community Operations Panel; Stack Gas Problem Working Group; Advisory Committee on Technological Information.

The AEC has brilliant experts in many phases of its work but it is SOP —standard operating procedure—to go outside your own bailiwick and get help when special problems arise.

▶ SELF-LUMINESCENT *materials activated by tritium come in two styles as made by Tracerlab, Inc. In one, tritium replaces hydrogen atoms in fluorescent materials such as trans-stilbene. In the other, a tritiated solid is mixed with an efficient phosphor, such as zinc sulfide. Decay of tritium corresponds to a loss of about 5% of the light output per year.*

We come now to the question that perhaps is of greatest interest to this group—the role of private management. You now know that practically all AEC work is done by private academic or industrial contractors. For the most part, the concerns involved stake their reputation but do atomic work on a no-risk basis—as far as capital is concerned. Some exceptions should be noted.

Domestic mining is very much on a risk basis. From two mills and 200 men, activity in the Colorado Plateau has increased to eight mills employing 1,000 men with another 4,000 persons

estimated to be involved in the expanding mining program. Only one of these mills is government owned. However, the AEC, under the law, is the sole customer. Guaranteed prices, bonuses for opening up new mines, haulage allowances and other aids have stimulated the mining of uranium to a point where tonnages being produced in our own country are exceeding all expectations.

You can purchase radioactive compounds from at least five commercial firms. The AEC manufactures the radio-isotopes, principally in the Oak Ridge reactor, but some of them are not in the form best suited for specialized uses. So, these firms buy them "wholesale," so to speak, and put them up in salable compounds. One company has a small branch factory located in the business section of Oak Ridge to turn out its compounds.

A "service" industry is growing rapidly. Starting from scratch with the advent of the atomic age, there are now 75 firms manufacturing items like thickness gauges, remote control instruments, special containers, Geiger counters and related equipment. Their volume has grown to about $20 million, which is not a large figure, but it has doubled in the past two years. As the use of the radioisotope expands —and there have been more than 30,000 shipments of these versatile tagged atoms—this new industry will continue to grow. This field includes the few firms that make cyclotrons and other particle energy accelerators the kind of atomic research machines that are finding a wider market these days—especially if the research institution can get financial support from the AEC.

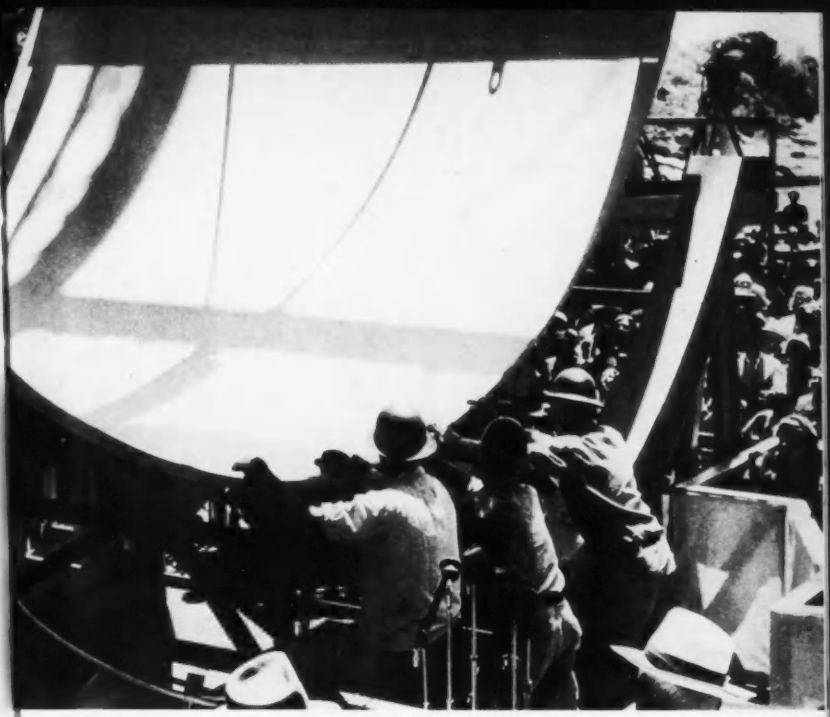
Private industry is just beginning to use radioisotopes in appreciable quantities on the assembly line. The rubber and plastics industries are using thickness gauges to save thousands of dollars annually in raw materials by reducing the spoilage of sheet due to uneven thickness. Cobalt units are employed by the metals trade in increasing numbers to detect flaws in boiler plates, welds and castings. The petroleum industry is using tracer atoms for tagging oil interfaces in pipelines, measuring catalyst circulation in the "cat crackers" and in oil well logging to turn up areas rich in oil sands.

There may be potential industrial uses in the so called waste fission products now expensively stored by the AEC in huge underground tanks like those at Hanford. Research has uncovered a number of potentially valuable applications. These may include such things as cold sterilization of drugs, hormones, antibiotics and—as a long-range possibility—sterilization of food: Also possible triggering of commercially important chemical reactions, activation of phosphors to yield low-level sources and other uses.

If the economics can be worked out, a sizable industry may spring up that buys these fission products in bulk and tailors them to various markets.

But the thing that has private enterprise and management most interested at the moment is the prospect of commercially produced nuclear power. A real challenge appears to be in the making here.

I am not going into the technical details. Useful power is already here but not economic power. Intermit-



—Gordon Baird Associates photo

▶ HULL OF THE *"Nautilus," first atomic powered submarine, began to take shape as this Lukens high tensile steel plate was swung into place at the keel laying ceremonies.*

tently, the AEC has been generating more than 100 kw of power at its Experimental Breeder Reactor in Idaho ever since the historic moment on December 20th of last year when a turbine was turned for the first time with steam made from the heat extracted from an atomic furnace.

Keep one fact always in mind. Scientists do not know or foresee any way to get power *directly* from the atom. What would happen would be the substitution of atom "stoves," for the present coal, oil, and gas fired boilers of power generating plants.

There have been several technical "breakthroughs" that promise to give greater efficiency in the use of fissionable material and to lower the cost of the chemical reprocessing of partly burned up nuclear fuel. Work is pro gressing rapidly on two types of reactors that will be the boilers of atom powered submarines. A contract has

been let for development work on a reactor for a large ship such as an aircraft carrier. Work has begun at our Idaho installation for experimentation in the field of atom powered planes.

Last year, four teams comprising eight utility, chemical and industrial firms made agreements with the AEC to finance at their own expense a year's study of the feasibility of reactor-produced power. Their reports are in and are described as "cautiously optimistic." One team has gone into the second stage of its study—the job of selecting and designing the particular kind of reactor they would propose to use. A fifth team just signed up to make its own initial studies.

There are intriguing long-range possibilities. Assuming that fissionable material will be available, the known reserves of uranium—with possibility of thorium as an added starter—have an energy potential that dwarfs that of all other fuels. The cost of fossil fuels is going up. We can expect the cost of nuclear power production to come down. Somewhere in the future, these cost curves will meet and the atom will be in the power business.

One short cut proposed is dual-purpose reactors that would make plutonium for Uncle Sam and get heat to generate power as a by-product. This assumes that the government can make a long-term commitment—say 25 years—so that the immense capital needed can be induced to invest in a private power project. However, some leaders like General Electric's Harry A. Winne believe this to be an unsound basis on which to found a new power industry and prefer to await the development of reactors efficient enough to stand alone as power producers.

This plutonium-power proposal highlights the several tough problems that AEC management faces in this developing situation. Atomic energy today is a tight monopoly—a government monopoly. The law says that the United States shall be the exclusive owner of all facilities for the production of fissionable materials as well as sole owner of the nuclear fuel itself. The law also says that all inventions in the area of fissionable material utilization shall be turned over to the government as non-exclusive, royalty-free patents.

But the law also says, in listing the objectives of the national program in the preamble, that ". . . . the development and utilization of atomic energy shall, so far as is practicable, be directed toward the strengthening of free competition in private enterprise . . . ." And the law further provides specifically for the AEC to report to the President whenever it thinks any "industrial, commercial or other non-military use of fissionable material of atomic energy has been sufficiently developed to be of practical value."

As we look across the threshold at the next major period in the development of AEC, the problems connected with the advent of civilian nuclear power challenge the imagination and skill of both the AEC and private industry. Commissioner Eugene M. Zuckert discussed this issue in detail before an American Chemical Society group in Chicago on September 11.

The first is the relationship between civilian power and national defense. The AEC must measure the effect of

any atomic power development against the needs of the military. This refers not only to weapons but to fissionable material for submarine and possibly aircraft fuel. What are the future demands and uses of plutonium? Would the AEC be justified in buying plutonium for stockpiling beyond the needs that are foreseeable at this time? On the other hand, if the power-plutonium proposal should be adopted, private capital will have to have some kind of long-term commitment because of the high initial investment involved.

Who is going to participate? If the number of participants in the program has to be limited, how is the AEC going to select the companies which would be allowed into the charmed circle? On the dual-purpose reactor basis, a price for plutonium must be worked out that will assure adequate incentive but not constitute an unjustified subsidy of atomic power. How do you strike that balance?

Should the government be responsible for health and safety within privately operated atomic plants? How far should the AEC go to compel plant operators to take the expensive safety measures that arise out of the lethal potentialities of radioactivity?

Security is a very real problem. Data on the efficiency of reactors and the manufacture of plutonium have a high intelligence value to a potential enemy. It seems that the AEC would have an obligation to make sure that only loyal and reliable employees have access to secret work in private industries' atomic plants. However, we could not expect the FBI to turn over its reports to private corporations.

Patents present a difficult problem. Commissioner Zuckert stated it this way: "At what stage in the cooperative development of atomic power does the private company begin to acquire rights? How do we insure equitable access to the know-how, developed at government expense, which must be the background for many patent developments?"

The AEC has a high stake in the efficiency and design of future reactors. In the development of a private nuclear power industry, it is our obligation to make sure that broad research activities in the nuclear field are continued at a satisfactory level.

On the Back Cover

▶ STEAM *from atomic energy produces 170 kilowatts of electric power in this Argonne National Laboratory installation. The atomic power comes from the Experimental Breeder Reactor. Extreme care is taken to prevent the liquid alkali metal of the reactor's cooling system from coming in contact with the water in the steam cycle.*

Hardness of Gem Stones Gives Industrial Value

Crystals of Commerce

Extract from the forthcoming book "Chemistry for Our Times," revised—Elbert C. Weaver, M.A., Phillips Academy, Andover, Mass., and Laurence S. Foster, Ph.D., Watertown Arsenal, Watertown, Mass.—McGraw-Hill Book Co., N.Y.—by permission of the authors and publisher.

➤ CRYSTALS are fascinating to people and always have been. The clear, brilliant colors of sapphires or rubies and the scintillating flash of a diamond are just as appealing to modern men and women as they were to the ancients.

Some people are surprised to learn that the *faces* of crystals are not cut but grow naturally as flat surfaces that meet other faces at definite angles. Natural diamonds sometimes crystallize as simple cubes. The brilliant gem that is used in jewelry is cut (ground and polished) with many *facets* (little faces). These facets are not natural crystal faces at all. They are located to give the best spark'e to the gem. Scientists are more interested in the orderly arrangement of natural crystal faces and what they show about what is within the crystal.

If an imperfect crystal of copper sulfate is hung in a saturated solution of copper sulfate in water (held at constant temperature and in a closed vessel to avoid evaporation), broken corners, rough faces, and irregular edges slowly mend. The crystal keeps the same weight but becomes more nearly perfect in form. The crystal dissolves at some spots; and, at the same rate, copper sulfate crystallizes at other spots. The repair is made by this equilibrium. The compound dissolves just a bit faster from sharp points and edges than from flat surfaces. It recrystallizes on the flat places in a perfectly orderly manner. This process makes the crystal gradually become closer to a truly regular form.

The regularity of a well-grown crystal is related to the inner arrangement of the crystal units. Copper ions (Cu^{++}), sulfate ions (SO_4^{--}), and the 5 molecules of water that make up hydrated copper sulfate fit into their proper places to form the crystal of the compound.

Not all commercial materials are allowed to grow into large crystals. Often small crystals are used, as in the case of table sugar. Coarse sugar crystals dissolve more slowly than fine. On the other hand, a mechanical'y ground sugar like confectioners' sugar does not flow well. So the size of sugar crystals is carefully controlled.

Many other substances are crystalline, but they have such small crystals that people are not aware of this fact. Examine a few grains of common salt (NaCl) with a magnifying glass. You see tiny cubic crystals, possibly with rounded edges caused by handling. In fact, all true solids are crystalline. Examination of solids by means of x-rays

makes a picture that shows a characteristic pattern for each crystalline substance. So-called amorphous (without form) materials may have finely divided crystals, or they may be a viscous (thick and sticky) liquid or a plastic (doughlike) mass, not true solids.

Rubies are always red in color. While blue is the characteristic color of sapphire, other colors such as white or yellow may be found. Both rubies and sapphires are crystalline varieties of the mineral corundum, which is alumina or aluminum oxide (Al_2O_3). They are extremely hard gems and are highly prized.

Large rubies and sapphires of gem quality are not common. The "Star of India," a star sapphire that weighs 563 carats, may be seen in the American Museum of Natural History, New York.

Gems are spectacular, but they are of far less practical importance in an industrial community than the small pieces of synthetic corundum used as jewel bearings in watches and precision instruments. In 1904, Auguste Victor Louis Verneuil (1856-1913) invented an inverted form of blowpipe to manufacture synthetic rubies and sapphires of a quality equal to natural gem stones. When the apparatus is put into operation, finely divided alumina (Al_2O_3), containing about 2.5 percent of chromic oxide (Cr_2O_3), is sprinkled down through a hot oxygen-gas flame. The particles melt and become attached to a pedestal to form a small pear-shaped mass, called a *boule*. The boule can be grown at the rate of 10 carats (0.2 g) per hour. This gem-quality, synthetic corundum boule is cut into thin slices and ground to the shape of instrument bearings by means of fine diamond dust. Watches may contain from 7 to 23 jewels.

Synthetic ruby bearings are inexpensive. They are priced in terms of cents, not dollars. Natural rubies the size of a boule have been sold for as much as $100,000. Chemically, synthetic and natural rubies and sapphires are slightly impure aluminum oxide.

Natural corundum, or aluminum oxide, that is colored black by impurities, is called emery. Crushed and sorted for size, this extremely hard material is used for abrasive (grinding) wheels, whetstones, and emery cloth. At the time the grains are glued to the cloth, a high electric potential (voltage) is applied. Under its influence, the sharpest cutting edges point outward and the grains space themselves evenly.

Experience shows that white grinding wheels run cooler than black ones. Hence, light-colored abrasives are in demand. When aluminum oxide is made by melting bauxite (hydrated aluminum oxide mineral) in an electric furnace, the product is usually light brown to white. Many tons of fused alumina are used each year to grind metals and to line furnaces. Perfectly white, crystallized alumina can also be made.

Masses of fused alumina grains may be pressed into desired shapes and *sintered* (made into a solid mass) in a gas-fired furnace at temperatures as high as 1800°C. Porous alumina firebricks and furnace cores are made in this way. Dense-wall, impervious chemical apparatus is made from high-purity alumina.

Comparison of Hardness Values

Substance	Formula	Mohs value	Knoop value*
Talc	$3MgO \cdot 4SiO_2 \cdot H_2O$	1	
Gypsum	$CaSO_4 \cdot 2H_2O$	2	32
Calcite	$CaCO_3$	3	135
Fluorite	CaF_2	4	163
Apatite	$CaF_2 \cdot 3Ca_3(PO_4)_2$	5	430
Feldspar (orthoclase)	$K_2O \cdot Al_2O_3 \cdot 6SiO_2$	6	560
Quartz	SiO_2	7	820
Zirconia	ZrO_2		1160
Beryllia	BeO		1300
Topaz	$(AlF)_2SiO_4$	8	1340
Garnet	$Al_2O_3 \cdot 3FeO \cdot 3SiO_2$		1360
Zirconium boride	ZrB_2		1550
Titanium nitride	TiN		1800
Tungsten carbide alloys	WC, 6% Co		1900
Corundum (synthetic sapphire)	Al_2O_3	9	1950
Zirconium carbide	ZrC		2100
Titanium carbide	TiC		2470
Silicon carbide	SiC		2480
Boron carbide	B_4C		2800
Diamond	C	10	7000

The minerals beryl, emerald, and aquamarine all have the composition shown by the formula $Be_3Al_2(SiO_3)_6$. Grass-green, gem-quality emeralds have long been ranked among the most costly of jewels. The hardness of beryl and emeralds is a little less than the hardness of sapphires.

Opaque beryl is the principal ore of beryllium. Beryllium is used in beryllium-copper alloys. Beryllium or beryllium oxide is also used as a *moderator* in nuclear reactors. Enormous natural crystals of opaque beryl have been found in Norway and elsewhere.

In Brazil, an aquamarine crystal was discovered that weighed 243 lbs. and yet was so perfectly formed and transparent that it could be seen through from end to end.

When two different substances are rubbed together, each is worn away, but the harder substance makes a far deeper scratch on the softer one. Hardness scales are based on this fact.

On the Mohs scale, which is the simplest scale of hardness, each substance on the list scratches those of lower hardness number. The divisions on this scale are not even. The Knoop scale, on the other hand, shows relative hardness more accurately. Using a measured force, a very small pyramidal diamond point is pushed into the material to be tested.

A comparison of the two scales,

* Acknowledgment is made to Dr. N. W. Thibault, Norton Company, Worcester, Massachusetts, for most of the Knoop hardness values.

shown in the table, emphasizes (1) the irregularity of the Mohs scale and (2) the superior hardness of a diamond.

The interest of chemistry students in diamonds may not be altogether chemical. Diamond is a form of carbon of remarkable hardness. It is a nonconductor of electricity. It is quite unlike soft, black, opaque, and electrically conducting graphite.

The differences between diamond and graphite are caused only by the ways in which the atoms of carbon are bonded together. Such different forms of an element are called *allotropic* forms. Diamond has carbon atoms, bonded to four neighbors in all directions through electron-pair bonds of great strength. In graphite, carbon atoms form layers in which each atom is held to only three neighbors by strong electron-pair bonds. In the other direction, vertical to the plane of the layers, the bond is very weak. Some of the electrons are held so weakly that they are free to move and conduct electricity. The layers can move over one another. The lubricating properties of graphite are explained by these layers. Graphite is slippery to touch. We explain the vast difference in properties between diamond and graphite by only slight differences in the arrangement of the atoms in the crystal. When heated to a high temperature, diamond changes to graphite. So evidently graphite is more stable.

Every year the freshman chemistry class in a certain college is called into the laboratory to see a special experiment. A diamond, previously exhibited, is burned in pure oxygen in a suitable apparatus by the chemistry instructor. The gas formed by burning the diamond is collected and run through limewater. A white precipitate of calcium carbonate forms. The chemical actions are

$$C + O_2 \rightarrow CO_2$$
$$CO_2 + H_2O \rightarrow H_2CO_3$$
$$H_2CO_3 + Ca(OH)_2 \rightarrow CaCO_3\downarrow + 2H_2O$$

This is convincing, but expensive, proof that a diamond is carbon. The experiment was first performed by Lavoisier.

Silicone Cream Protects Skin

➤ SILICONE fluids are widely used in industry, and now one of them, polymethyl siloxane, has been made into a cream to protect the skin of industrial workers.

Good results with the cream in a trial in one industrial plant were reported by Dr. Raymond R. Suskin of the University of Cincinnati College of Medicine at a recent meeting of the American Medical Association.

The cream is made with 52.5% silicone fluid mixed with the inert clay, bentonite. It can be put on the skin as a thin, inconspicuous film at the beginning of the work day and removed at the end of the work period. No harmful effects from it were seen after seven months continuous use.

Inventions Just Patented Use Chemical Materials

Recent Chemical Patents

To obtain copies of any patents, order by number from the Commissioner of Patents, Washington 25, D. C., enclosing 25 cents in cash, money order or Patent Office Coupon for each one ordered. Do not send stamps.

TV Color Tube

➤ A TELEVISION picture tube has been patented which uses a gridwork of phosphorescent chemicals and metal to reproduce full-color images of video shows on its screen.

The color tube's gridwork consists of tiny lines of phosphors that glow red, green and blue, respectively, when bombarded by electrons from the tube's "gun." Tiny strips of metal separate the groups of phosphors.

As the picture is received, the electron beam sweeps the appropriate phosphor lines. For instance when red appears in the picture, electrons are released which strike the "red" phosphors. When viewed as a whole, the gridwork produces a color picture on the screen.

The system hinges upon making the electron beam travel straight across the screen along the narrow phosphor lines. If the beam gets off the proper phosphor, the color picture will not be as it should.

To keep the electron beam in register with the phosphors, tiny strips of metal are interposed between groups of three phosphors. When the electron beam "jumps the track" and strikes a metal strip, corrections are fed into an auxiliary deflection system of the tube to position the beam where it should be.

Inventor Hunter C. Goodrich of Collingswood, N.J., assigned his patent, No. 2,634,326 to the Radio Corporation of America.

Growing Grass

➤ A LAYER of gravel topped with a layer of bituminous emulsion over the seed bed of a grass lawn gives remarkable results in the speeding up of the germination of the seed, according to a British inventor who patented this method.

The bituminous emulsion keeps out water from the atmosphere and also prevents evaporation of water in the soil. The inventor finds that the grass then draws up just the right amount of water from underneath and that the temperature is raised, thus providing a sort of hothouse atmosphere. The gravel is provided because the young shoots of grass are, at first, too tender to push their way through the bituminous emulsion. However, once they grow through the gravel, it is claimed, they are tough enough to break through the top layer. Once the grass pushes through, more moisture from the atmosphere can get into the ground through the holes made by the blades.

Inventor is Thomas F. N. Alexander, Bristol, England, and his patent number is 2,632,979.

Fabric Printing

▶ A NEW KIND of pigment which provides great resistance to laundering, wet abrasion, dry abrasion, dry cleaning and with other advantages has been invented. The trick, the inventors say, is in a new resin binder for the pigments.

The new resin binder, used in water emulsion textile colors, is a polyester formed by a condensation process. The condensation products are resinous in character. The binders are called E-polyester resins.

Laszlo Auer, South Orange, N. J., is the inventor and he received patent number 2,637,621 for the new binder.

Plants Without Soil

▶ GROWING plants without soil is made considerably less expensive and more efficient with the help of a new method of getting the nutrient so'ution to the plant roots.

Waterproof beds are provided for the plants. At a certain distance above the bottom of the beds a perforated plate or piece of gauze is attached. On top of this is spread a chemically inert material, such as gravel, into which the plants are stuck. Their roots come out below the gauze. The nutrient solution necessary to the plants' growth comes from a lower reservoir and is circulated around the roots through the means of gutters. Once circulated it falls freely back into the reservoir.

The advantage of this method, the inventors claim, is that more oxygen is provided to the plant roots. The solution is aerated during its free fall back into the reservoir.

The new method was tried out in a greenhouse with pinks. The same kind of plants were grown with an old method in which the nutrient solution is not aerated. After six weeks the production of solids per plant was 30% higher in the new plant beds. The pinks gave flowers 18 days sooner with the new method and 12% more flowers were produced after one half a year.

The inventors are Gerrit Jan Hillegondus Ebbinge Wubben and Abram Arie Steiner of The Hague, Netherlands, and they assigned their patent, number 2,639,549, to Nederlandse Centrale Organisatie Voor Toegepast-Natuurwetenschappelijk Onderzoek, The Hague.

Volcanic Insulation

▶ A BETTER method for making insulating material for walls from volcanic ash or dust has been invented. Lightweight concrete can be made with the product too.

Dense glassy shards of unconsolidated volcanic rock are converted to lightweight cellular particles by quickly heating them to a viscous thermoplastic condition while they are suspended in flight through a flame. Then they are passed through another chamber where they are suddenly cooled off.

The light cellular material is then ready for use. Inventor is Albert L. Burwell, Norman, Okla., and he has assigned his patent, No. 2,637,702, to the University of Oklahoma Research Institute.

Projects Which Young Scientists Have Shown at Science Fairs

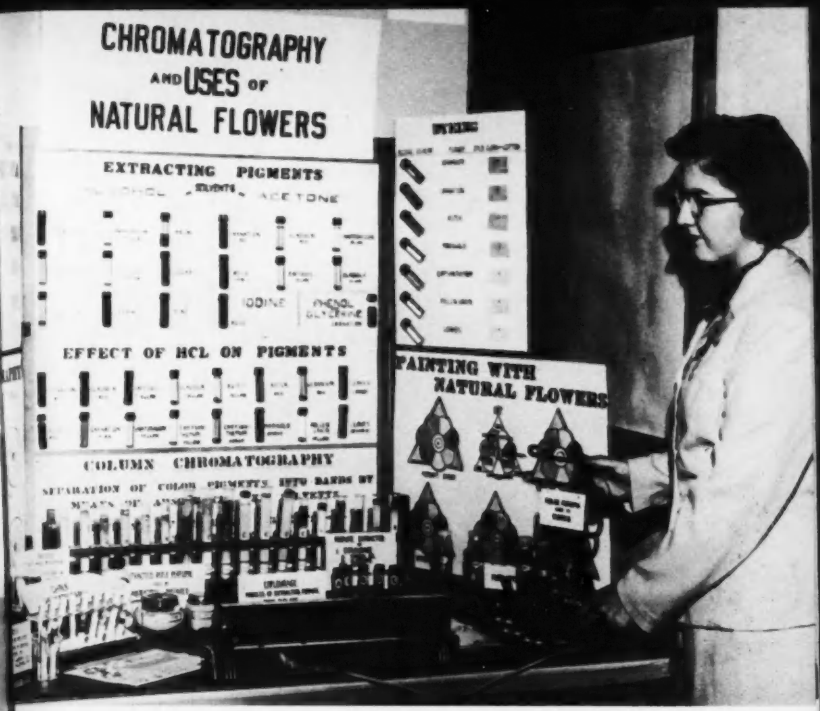
Experiments For Exhibits

➤ EACH YEAR a third of a million young people in the 15,000 Science Clubs of America find joy in learning by constructing science exhibits.

Some, like Albert Petersen, whose exhibit at the Fourth National Science Fair is shown at the bottom of this page, pick a project that they want to learn more about and build a model of an operation they have never seen.

Others bring to school examples of things that have interested them for years. Young collectors of insects or minerals or plants or many other natural objects often are well started on their hobbies before they leave grade school. They enjoy showing to classmates and teachers the interesting

➤ WITHOUT *ever having seen a steel mill, Albert C. Petersen, of Unionville, Conn., a senior at Farmington High School, studied the processes of iron and steel making and designed a model with cut-away sections to show what is accomplished at each step in winning the metal from the ore. Finalist at the Fourth Annual Northern Connecticut Science Fair, he was sponsored at the National Science Fair, at Oak Ridge, Tenn., by The Hartford Times.*



CHROMATOGRAPHY *of pigments from flowers and extraction of their perfumes were demonstrated at the National Science Fair at Oak Ridge, Tenn., by Claire G. Villandre, senior at Notre Dame High School, Central Falls, R.I. She was a finalist of the Eighth Annual Rhode Island Schools' Science Fair and was sponsored by The Providence Journal.*

things they have discovered in the world around them.

Science clubs in schools give the opportunity for young scientists to get together as they love to do, to talk shop and exchange ideas. Soon the experiments, the collections and the models create a demand for a place and time to show them, and a school science fair is the natural result.

School fairs lead to city-wide fairs and regional fairs, with the best exhibits representing their schools in competition with representatives of schools from other localities. But the meeting of young scientists from different regions and the inspiration they get from finding friends with similar interests is of far greater value to the participants than merely winning one more trophy.

All over the country, a new sense of fellowship in science is bringing together students, teachers, professional

➤ AUTORADIOGRAMS *and how to make them constituted the work shown at Oak Ridge at the National Science Fair by Douglass Gray Saunders, a sophomore at Oak Ridge High School. His exhibit won honors at the Southern Appalachian Science Fair, and was sponsored by the Knoxville News-Sentinel.*

scientists and community leaders, in Science Clubs of America.

Boys and girls learn about their projects by building interesting science exhibits to show at the science fairs.

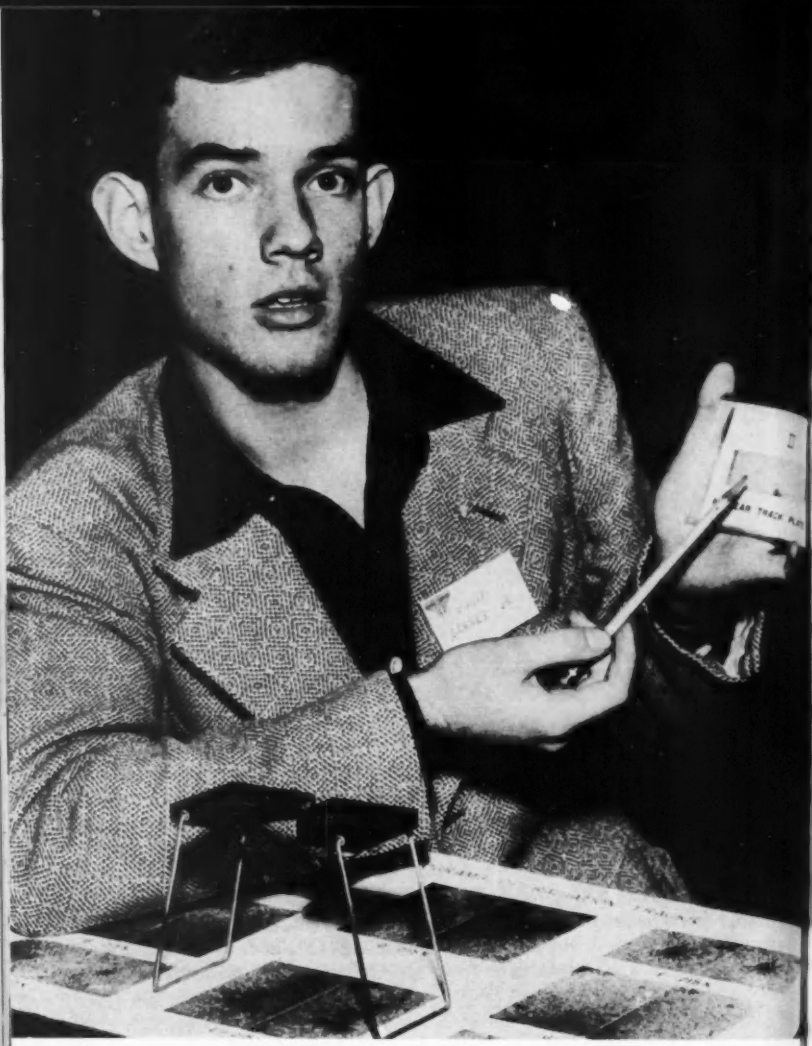
As an impetus toward finding careers in science for young people, Science Service, through Science Clubs of America, sponsors the National Science Fair as the culmination of regional fairs. Newspapers of the areas cooperate with citizens of their communities to send regional winners to represent them at the national fair.

Last May at Oak Ridge, Tenn., 30 localities were represented by 71 finalists at the Fourth Annual National Science Fair. Next spring the Fifth National Science Fair will be held at Purdue University, Lafayette,

▶ STEPS *in the process of preparing chromium and its compounds from chromite ore made up the exhibit which Willard Loye Madson took to the National Science Fair at Oak Ridge. He built the flow chart of the process of illuminated lucite. A senior at the Pierre S. du Pont High School, Wilmington, he was a winner in the Delaware State Science Fair and was sponsored by the Wilmington News-Journal.*

Ind., in May. About a hundred young scientists from more than 50 fairs are expected there.

This fall both in classes and in the out-of-school-hours clubs, both boys and girls will be planning and working on the experiments that they will show at the fairs next spring. Those entering junior high school are being encouraged to start ther projects so that they have plenty of time to try out several ideas before they hit upon one that they wish to exhibit. The more experienced science club members are being put in touch with professional chemists and other scientists when they come up against problems for which they need more information. There is never a dull moment in doing these science projects. And they pay off in fun as well as in experience.



➤ SHOWING *how he analyzed radioactive minerals by thick-emulsion photography is Virgil E. Barnes, II, High School senior, of Austin, Texas, whose account of his method of working on this project will give valuable pointers to other young researchers.*

An Investigation of Radioactive Materials

Thick-Emulsion Photography

by VIRGIL BARNES II.

This research report by one of the 40 Trip Winners in the Twelfth Annual Science Talent Search records an interesting study of techniques in calculating the amount of radioactive material present in rock samples from tracks in photographic emulsions.

➤ I FIRST became interested in thick emulsion photography for studying radioactivity when I learned that this method rivals the Wilson cloud chamber and even exceeds it in usefulness in certain fields of atomic particle study. Both photographic emulsions and the cloud chamber are used to make records of the tracks of subatomic particles. Thick emulsions can only record tracks passing between the two surfaces of the emulsion, but this disadvantage is compensated by the fact that thick emulsions can record continuously events happening over a period of time, whereas the cloud chamber is not a continuous recorder. And when working with radioactive rocks thick emulsions are distinctly superior, showing the intensity and distribution of radioactivity and making possible determination of the types of emitters present by measurement of the lengths of separate tracks in multiple emissions from the emitters under question.

My line of investigation up to the present has been to place powdered samples of radioactive minerals on 100 micron emulsions and then to attempt to calculate the uranium content of an unknown mineral by comparing the density of tracks produced by it with the track density from a known sample. Five minerals were used and are as follows: pitchblende—3.36% U_3O_8, carnotite—0.18% U_3O_8, carnotite—0.11% U_3O_8, phosphate rock of unknown uranium content, and an unknown mineral of moderate activity. The first three samples, with uranium percentages given, were obtained from the New Brunswick Laboratory of the U. S. Atomic Energy Commission.

The exposures were made on "nuclear research" emulsions, the plates used being made in England by Ilford Ltd. The emulsions, 100 microns thick, are on glass backings one by three inches in size. These plates are developed differently from normal plates, in that either the development time must be increased or the temperature of the developer must be raised. I chose to develop the plates using a long developing time. The total developing time is ten hours, for seven hours of which the solutions must be agitated constantly. I used a Tinker-toy motor to drive an agitating device—I doubt that anyone would have had the fortitude to do it manually.

The phosphate rock and the unknown were prepared for exposure by grinding to minus 200 mesh, which approximates the fineness of the stan-

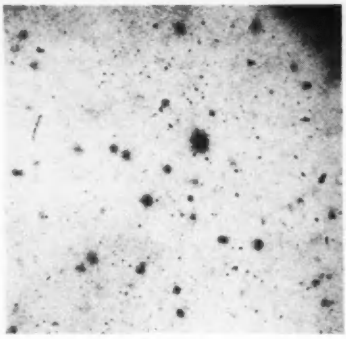


FIG. 1.

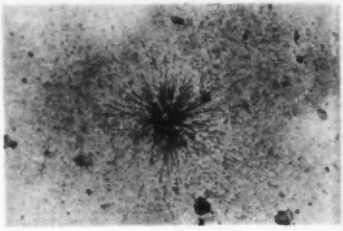


FIG. 2.

dard samples from the Atomic Energy Commission. A uniform weight of each sample was tested with a Geiger counter to obtain a rough estimate of their relative radioactivity. Such an estimate helps in determining the length of exposure for the samples. An aluminum plate approximately one-sixteenth inch thick and having five quarter-inch holes drilled in it was placed over the emulsion side of the nuclear plate. Each hole was filled with one of the five samples, no attempt being made to level the piles of powder to the surface of the plate. The samples were left for 24.5 hours, then development of the plate was started immediately.

The developed plate was examined under about 500X magnification. The phosphate rock averaged about 2.3 tracks per counting field. The pitchblende was much the strongest, averaging 210 tracks per field (Table I). The tracks are unevenly distributed (Figs. I-IV), therefore, from six to ten fields were counted per sample and then averaged. In checking accuracy, the three standard samples were used as reference, the ratio of two uranium percentages being compared with the ratio of the corresponding track densities. The difference, or error, between the pitchbende count and the count of the 0.18% U_3O_8 carnotite was found to be 6%. Between the pitchblende and the other carnotite the error is 25%.

TABLE I

MINERAL	Phosphate Rock	Unknown	Pitch-blende	Carno-tite	Carno-tite
U_3O_8	0.05 ±0.013%	0.49 ±0.12%	3.36%	0.18%	0.11%
GEIGER COUNT (counts per minute)	40	420	1600+	220	100
TRACKS PER FIELD 24.5 hour exposure	2.3	40.3	210	11.5	8.8
TRACKS PER FIELD 171 hour exposure	33.8	325	too dense to count	129	65

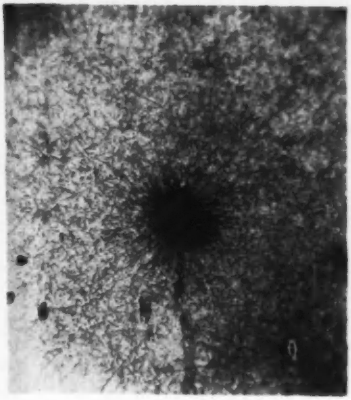


FIG. 3

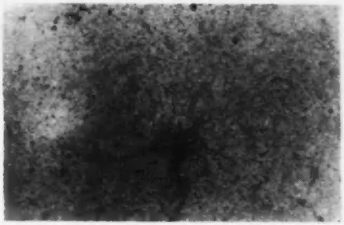


FIG. 4

As there is a statistical variation of the decay rate of radioactive elements, I decided to try a longer exposure in hopes of greater accuracy. This time, as the aluminum cover plate had caused deterioration in some parts of the emulsion, it was dispensed with. The powders were poured onto adjacent parts of one plate to a depth of approximately one-eighth inch and the plate exposed 171 hours. This method of plate loading gives some chance of cross contamination. Upon development the pitchblende tracks were too dense to count (Fig. III). The other two standards were used, and were found to have an error of 21%. The corresponding error for the 24.5 hour exposure was 27%. Increasing the exposure time seemed to have helped, but a large error was still present. Using the 171 hour exposure, tentative uranium percentages were calculated for the phosphate rock and the unknown (Table I). An error of 25% was allowed, considering the error between the two standards. Of course, the element responsible for the radioactivity might not even be uranium. It could be thorium, for example.

Some better way of determining which radioactive mineral is in a rock and how much of it is present should be possible. In both exposures, the

TABLE II

MINERAL	Phosphate Rock	Unknown	Pitchblende	Carnotite	Carnotite
GEIGER COUNT of residue after aqua regia	20	160	540	80	60
GEIGER COUNT of liquid from leaching	20	100	620	60	80
TRACKS PER FIELD with residue 171 hour exposure	no tracks	spoiled emulsion	91	7.7	7.8

powder tended to adhere to the emulsion, obscuring the tracks. The distribution of radioactivity through the powder was not uniform (Figs. I and II). Weighed quantities of the various samples should have been used, taking into consideration the transparency of the minerals to radioactivity.

It occurred to me that if the radioactive fraction of a weighed sample could be dissolved while leaving the bulk of the sample undissolved, and the liquids obtained concentrated by evaporation and rendered harmless to photographic emulsion, the problems of adhering particles and uneven distribution would be solved. Upon allowing such liquids to soak into an emulsion, the emitting nuclei would be embedded. Then with no obscuring particles present and with a more even radioactivity distribution, more accurate track counts could be made and multiple emissions could be better studied. The measurement of multiple emissions makes possible the determination of the radioactive elements present. By comparing the lengths of several tracks from one nucleus the nucleus can be identified by its characteristic sequence of alpha, beta, and gamma emissions. Knowing which radioactive elements are present, one can correct for them and give accurately the percentage of a particular element.

Attempts were made to leach the various samples, first in HNO_3 and later in aqua regia. Neither of the reagents leached all of the radioactive fraction, as was shown by Geiger tests. Also, when neutralization of the liquids was attempted, a heavy precipitate formed. As a rough check of the radioactivity remaining in the samples, and as a check of the effect of the chemicals present upon the emulsions, uniform weights of the five samples were leached in aqua regia, the residues and their corresponding liquids (Table II) were measured with a Geiger counter, and the residues then heated to dryness. The dried residues were placed on a nuclear emulsion and left for 171 hours. The liquids could not be used since they could not be neutralized and when evaporated to dryness the residues were deliquescent.

After development of the plate exposed to the residues, counts were made except for portions of the plate that were ruined (Table II). A slight deliquescence, perhaps caused by unremoved salts, spoiled the emulsion under the residue of the unknown. No tracks were observed from the residue of the phosphate rock, and as this residue gave a positive reaction on the Geiger counter, some agent—deliquescent salts and/or active chemicals—must have desensitized the emulsion. The three standard samples show a considerable decrease in radioactivity, the average activity being less than 10% of that of the original sample.

Although I have obtained no usable data yet by leaching, I have hopes that with further experimentation I can find a practical method for selectively dissolving the radioactive fraction of a sample, and a method for rendering the solutions obtained harmless to photographic emulsions. I shall also try other uses of "nuclear research" emulsions for measuring radioactivity in rocks. I shall be well satisfied if my further research proves as fascinating and instructive as my present work has been.

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